PATENT ABSTRACTS OF JAPAN

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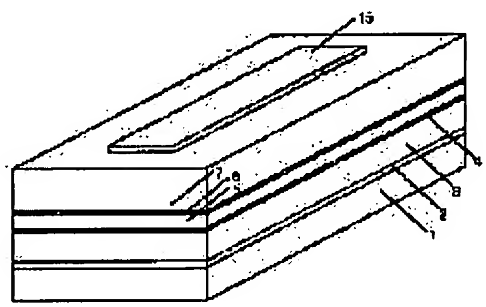
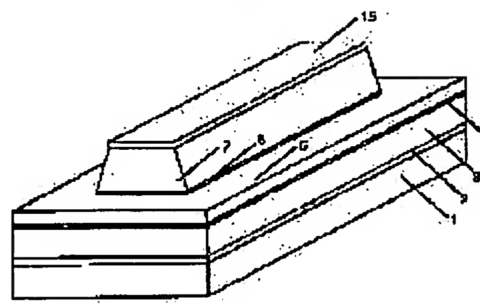
(54) SEMICONDUCTOR LASER DEVICE AND METHOD OF FABRICATING THE SAME

(57)Abstract:



:a)



(b)

PROBLEM TO BE SOLVED: To provide a semiconductor laser device in which a ridge is formed in an area other than around a laser end face and a quantum well structure consisting of an active layer which is not positioned around the ridge and an active layer of the laser end face is made in a mixed crystal state, thereby making the active layer of the laser end face transparent for a laser beam with excellent controllability without causing damages or rapid deterioration to the boundary face.

SOLUTION: On a substrate 1, a buffer layer 2, a clad layer 3, a distortion quantum well active layer 4 constructed by a barrier layer and a strained quantum well layer, a clad layer 5, an optical waveguide and etch stop layer 6, and a clad layer 7 are sequentially formed by an MOCVD method. An SiO2 oxide layer 15 is formed on the clad layer 7, and the clad layer 7 is etched with concentration hydrochloric acid by using the layer 15 as a mask, thereby forming a ridge. Further, the optical waveguide and etch stop layer 6 is removed. After that, the substrate on which the ridge is formed is conveyed into an ion implanter and a hydrogen ion is implanted so that the quantum well structure except for a part around the ridge has the mixed crystal. The active layer of the end face can be made transparent for the laser beam.

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DETAILED DESCRIPTION

16
19, 20, 21, 22

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the high power semiconductor laser equipment which has a ridge, and its manufacture approach.
[0002]
[Description of the Prior Art] 0.98 micrometers currently briskly studied as current and the light source for rare earth addition optical fiber amplifier excitation By high power laser, such as band semiconductor laser, a laser edge surface part serves as an absorption field of a laser beam by generation of heat by the leakage current through the interface state density in an end face etc., and optical damage (Catastrophic Optical Damage:COD) in the field by generation of heat serves as hindrance of high-reliability-izing of laser, and a high increase in power. On the other hand, it is proposed in order that the structure which is made to mixed-crystal-ize quantum well structure which an edge surface part is made to diffuse Zn in JP,63-56979,A, and becomes it from AlGaAs and GaAs, makes the band gap of the barrier layer of an edge surface part larger than the band gap of the barrier layer of the other field, and makes an edge surface part a transparence field to a laser beam may realize high-reliability-izing of laser, and a high increase in power. Moreover, performing implantation of ion as the technique of mixed-crystal-izing of the quantum well structure of a barrier layer is proposed by JP,1-319981,A.
[0003]
[Problem(s) to be Solved by the Invention] In order to guide light stably, several micrometers clad layer thickness is required of semiconductor laser. For this reason, in the case of diffusion of the atom to the barrier layer which let the conventional cladding layer pass, or ion, or implantation, diffusion of long duration and the implantation of high energy were required. For this reason, the damage by the fall of the interface steepness by the counter diffusion within the quantum well structure of barrier layers other than the edge surface part by prolonged heat treatment and implantation as shown in drawing 5 (a) arose, and the fall of the dependability of a component or a property was caused. Moreover, long-distance implantation and prolonged diffusion caused the substrate of implantation, the diffused ion, or an atom, and horizontal diffusion, and the problem was in the controllability of the field of the barrier layer which performs mixed-crystal-izing and disordering (drawing 5 (a), (b)). As for this invention, a controllability aims the barrier layer of a laser edge surface part at mixed-crystal-ization or carrying out disordering, without causing the fall of the steepness of such a damage or an interface.
[0004]
[Means for Solving the Problem] The cladding layer which has the first conductivity by which this invention was formed on the semi-conductor substrate which has the first conductivity in order to attain the above-mentioned purpose, And it sets to the semiconductor laser equipment which consists of a ridge formed of the barrier layer which has quantum well structure, the cladding layer which has the second conductivity, and the cladding layer which has said second conductivity. A ridge is formed to fields other than near the laser end face (that is, it estranges from a laser outgoing radiation end face -- making). And after forming a ridge, quantum well structure of barrier layers other than near the ridge and the barrier layer of a laser edge surface part is mixed-crystal-ized, or disordering of the natural superlattice or the superlattice formed artificially of a barrier layer is carried out. The implantation of diffusion of Zn, Si, or Se, H, As, P, Ga, Zn and Se, Si ion, or an atom can be used for mixed-crystal-izing or disordering.
[0005] Thus, after forming the ridge in addition to the edge surface part and forming a ridge, the cross section of a vertical edge surface part was shown in drawing 6 R> 6 to the end face at the time of performing diffusion and implantation. In this case, what is necessary is for diffusion and implantation to be short time more, and just to perform them by low energy, since the distance of diffusion or implantation is hundreds of nm as shown in drawing. For this reason, the rarefaction of an end face can be realized, without producing horizontal diffusion to the substrate of the diffusion kind by whom of the interface by the damage and counter diffusion of implantation, and heat treatment of long duration, and

an implantation kind.
[0006] Moreover, diffusion or when implantation is carried out, as it is shown in drawing 7 , a substrate and the horizontal leakage current can also reduce the atom or ion which forms a crystal into a half-insulation like H, and properties, such as a threshold current of laser and effectiveness, can be improved. Since a current furthermore is not injected into an edge surface part in this case but generation of heat of an edge surface part is controlled, together with the end-face rarefaction, a high increase in power and high-reliability-ization are attained more.
[0007]
[Embodiment of the Invention]
<Example 1> The 1st example of this invention is explained using drawing 1 and drawing 2 . Drawing 1 (a) shows structural drawing and drawing 1 (b) shows the enlarged drawing of a barrier layer.
[0008] First, the production approach of a component is described. The n-InGaP cladding layer 3 (1.5 micrometers of clad thickness) which carried out lattice matching to the GaAs buffer layer 2 and the GaAs substrate on the n-GaAs substrate 1, An In1-xGaxAsyP1-y barrier layer (x= 0.82, y= 0.63, 35nm of barrier layer thickness) The deformation amount child well barrier layer 4 which consists of 8 and 10, and an InzGa1-zAs deformation amount child well layer (z= 0.16, 7nm of well thickness) 9, the p-InGaP cladding layer which carried out lattice matching to the GaAs substrate () [clad thickness 0.25micrometer] 5, the dirty [p-GaAs optical waveguide-cum-] stop layer 6, and the p-InGaP cladding layer (0.65 micrometers of clad thickness) 7 that carried out lattice matching to GaAs -- MOCVD -- sequential formation is carried out by law.
[0009] Next, it is SiO2 with a die length [of 900 micrometers], and a width of face of 5 micrometers on the p-InGaP cladding layer 7. It is p-InGaP by concentrated hydrochloric acid, forming an oxide film 15 (drawing 2 (a)), and using it as a mask. A cladding layer 7 is etched and a ridge is formed (drawing 2 R> 2 (b)). Next, the etching reagent of a sulfuric-acid system removes the dirty [p-GaAs optical waveguide-cum-] stop layer 6. The substrate which formed the ridge after that was conveyed in ion implantation equipment, and the hydrogen ion was poured in. Thereby, they are InGaAs/InGaAsP other than near the ridge. A quantum well mixed-crystal-izes.
[0010] Next, a substrate is again carried in in an MOCVD system and selective growth of the n-InGaP current constriction layer 11 is carried out. A wafer is taken out from the epigenesis length furnace, and the oxide film 15 used as a selective growth mask by etching is removed. Then, the p-GaAs contact layer 12 is formed. After forming the p lateral electrode 13 and the n lateral electrode 14, cleavage of the location of 25 micrometers was carried out from the ridge edge like drawing 1 (a), and the laser component of about 950 micrometers of cavity length was obtained.
[0011] Then, it is SiO2 of lambda/4 (lambda: oscillation wavelength) of thickness to the front face of a component. It is the low reflective film to twist to the rear face of a component SiO2 The high reflective film by four layer membranes which consist of a-Si was formed. Then, the plane of composition was turned down and bonding of the component was carried out on the heat sink.
[0012] After performing an ion implantation, as a result of picking out a substrate from an MOCVD system, without performing embedding growth and a micro phot luminescence measuring device's estimating, to the phot luminescence peak wavelength of the barrier layer of the ridge lower part having been 975nm, the peak wavelength of an edge surface part is 950nm, and it has checked that quantum well structure had mixed-crystal-ized by impregnation of a hydrogen ion.
[0013] Carrying out room temperature continuous oscillation of the component made as an experiment with about 10mA of threshold currents, the oscillation wavelength was about 980nm. The end-face destructive optical output (Pc) was 600mW, and the ridge was formed to the edge surface part and it improved sharply compared with 350mW of the component which did not pour in a hydrogen ion. This is based on the effectiveness of the rarefaction of the end face to the laser beam by the band gap of an edge surface part being expanded.
[0014] Moreover, when carrying out the 100mW constant optical output continuation drive under conditions with an environmental temperature of 80 degrees C about 30 elements, an initial drive current is about 140mA, and operated to stability with all components for 100,000 hours or more.

[0015] Before forming a ridge, also about the case where a hydrogen ion is poured in, the component was produced in the same procedure. In this case, since the distance made to pour in was long, in order to have obtained the shift of the band gap of sufficient barrier layer, the hydrogen ion by the high voltage needed to be accelerated. For this reason, the defect had to be formed so much during the crystal, the threshold current of a component of the initial drive current in a 100mW constant optical output could not but be as high as 200mA under conditions with a 20mA environmental temperature of 80 degrees C, and the average life of a component could not but be about 1000 hours.
[0016] These things show that it is effective for improvement in the property of a component, and dependability to perform an ion implantation after formation of a ridge. In addition, although the rarefaction of laser end-face both sides was performed in this example, the same effectiveness was acquired even if only the outgoing radiation side of a laser beam performed the rarefaction. Moreover, the same effectiveness as a hydrogen ion was acquired also by the implantation of As, P, Ga, Zn, Se, or Si ion.
[0017] <Example 2> The 2nd example of this invention is explained using drawing 3 and drawing 4 . Drawing 3 (a) shows structural drawing and drawing 3 R> 3 (b) shows the enlarged drawing of a barrier layer. Next, the production approach of a component is described.
[0018] It is the GaAs buffer layer 17, the n-(aluminum0.6Ga0.4)0.5In0.5P cladding layer (1.5 micrometers of thickness) 18, and 0.5(aluminum0.5Ga0.5) In0.5P on the n-GaAs substrate 16. Barrier layer 24 (5nm of barrier layer thickness) And 26 and an In0.5Ga0.5P quantum well layer The quantum well barrier layer 19 which consists of 25, the p-(aluminum0.6Ga0.4)0.5In0.5P cladding layer (0.3 micrometers of thickness) 20, the p-GaAs dirty stop layer (2nm of thickness) 21, p-(aluminum0.6Ga0.4) 0.5In0.5P cladding layer (8nm of well thickness) (1.0 micrometers of thickness) 22 and the p-In0.5Ga0.5P cap layer 23 (20nm of thickness) -- MOCVD -- law or the gas source MBE -- sequential formation is carried out by law. Next, it is SiO2 with a die length [of 900 micrometers], and a width of face of 5 micrometers on the p-In0.5Ga0.5P cap layer 23. It is the p-In0.5Ga0.5P cap layer 23 and p-(aluminum0.6Ga0.4)0.5In0.5P at concentrated hydrochloric acid, forming an insulator layer 31 (drawing 4 (a)), and using it as a mask. A cladding layer 22 is etched and a ridge is formed (drawing 4 (b)).
[0019] Next, the etching reagent of a sulfuric-acid system removes the p-GaAs dirty stop layer 21. The substrate which formed the ridge after that is conveyed in an MOCVD system, and it anneals at 600 degrees C in a phosphine (PH3) and a dimethyl zinc (DMZn) ambient atmosphere for 2 hours. Zn is spread in solid phase by this annealing, and disordering of the natural superlattice of an InGaP quantum well is carried out. Next, supply of dimethyl zinc is stopped, temperature is raised to 650 degrees C in a phosphine ambient atmosphere, and after temperature is stabilized, selective growth of the n-GaAs current constriction layer 27 (0.8 micrometers of thickness) is carried out.
[0020] A wafer is taken out from the epigenesis length furnace, and the oxide film 31 used as a selective growth mask by etching is removed. Then, the p-GaAs contact layer 28 (0.8 micrometers of thickness) is formed. After forming the p lateral electrode 29 and the n lateral electrode 30, as shown in drawing, cleavage of the location of 25 micrometers was carried out from the ridge edge, and the laser component of about 1000 micrometers of cavity length was obtained.
[0021] Then, it is SiO2 of lambda/4 (lambda: oscillation wavelength) of thickness to the front face of a component. It is the low reflective film to twist to the rear face of a component SiO2 The high reflective film by four layer membranes which consist of a-Si was formed. Then, the plane of composition was turned down and bonding of the component was carried out on the heat sink.
[0022] After being spread, as a result of picking out a substrate from an MOCVD system, without performing embedding growth and a micro phot luminescence measuring device's estimating, to the phot luminescence peak wavelength of the barrier layer in the waveguide of the ridge lower part having been 875nm, the peak wavelength of an edge surface part is 650nm, and it has checked that the natural superlattice of the quantum well layer of an edge surface part was carrying out disordering by diffusion of Zn.
[0023] Carrying out room temperature continuous oscillation of the component made as an experiment

with about 40mA of threshold currents, the oscillation wavelength was about 685nm. The end-face destructive optical output (Pc) was 85mW, and the ridge was formed to the edge surface part and it improved sharply compared with 40mW of the component which did not diffuse Zn. This is based on the effectiveness of the rarefaction of the end face to a laser beam by the band gap of an edge surface part being expanded.

[0024] Moreover, when carrying out the 30mW constant optical output continuation drive under conditions with an environmental temperature of 60 degrees C about 30 elements, an initial drive current is about 90mA, and operated to stability with all components for 100,000 hours or more.

[0025] Before forming a ridge, also about the case where Zn diffusion is performed, the component was produced in the same procedure. In this case, since the distance to diffuse was long, in order to have obtained the shift of the band gap of sufficient barrier layer, it needed to anneal at 600 degrees C in the phosphine (PH3) and the dimethyl zinc (DMZn) ambient atmosphere for 8 hours. For this reason, also in the barrier layer except having diffused Zn, the steepness of an interface could not but fall by the counter diffusion of an interface, the threshold current of a component of the initial drive current in a 30mW constant optical output could not but be as high as 120mA under 60mA and conditions with an environmental temperature of 60 degrees C, and the average life of a component could not but be about 10,000 hours. This shows that it is effective for improvement in the property of a component, and dependability to perform diffusion after formation of a ridge.

[0026] In addition, although the rarefaction of laser end-face both sides was performed in this example, the same effectiveness was acquired even if it performed only the outgoing ~~radiation side of a~~ laser beam. Moreover, the same effectiveness as Zn diffusion ~~was acquired~~ also by diffusion of Si or Se.

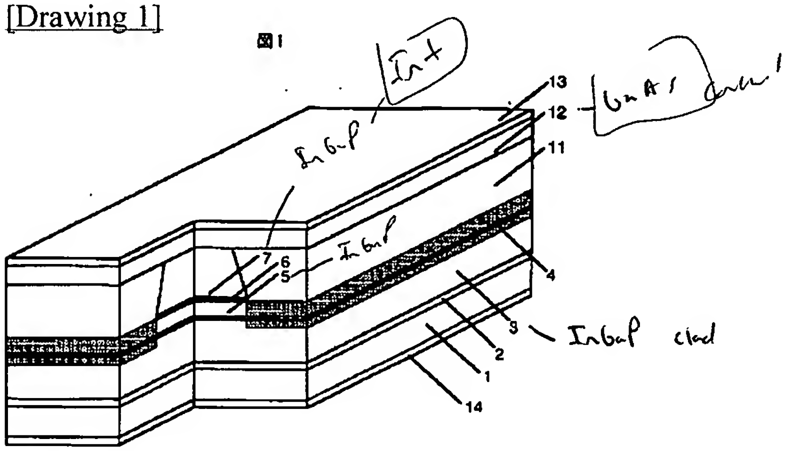
[0027]

[Effect of the Invention] By this invention, the rarefaction of the barrier layer of an edge surface part can be carried out to a laser beam, without reducing the crystallinity of high power semiconductor laser, and the steepness of the interface in quantum well structure, and high-reliability-ization of high power semiconductor laser can be realized.

DRAWINGS

[Drawing 1]

図1



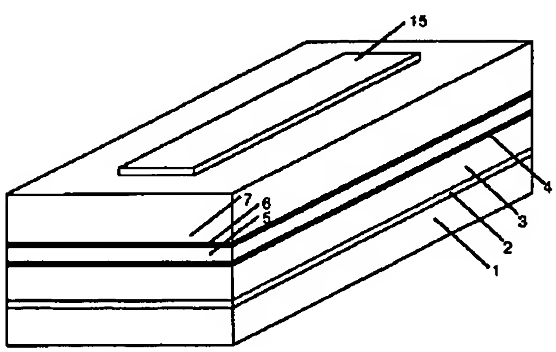
(a)

A部（活性層部）拡大図

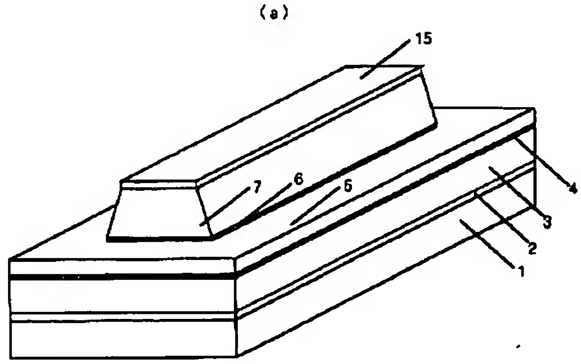
(b)

[Drawing 2]

図2



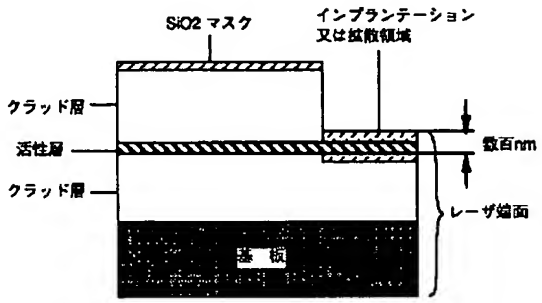
(a)



(b)

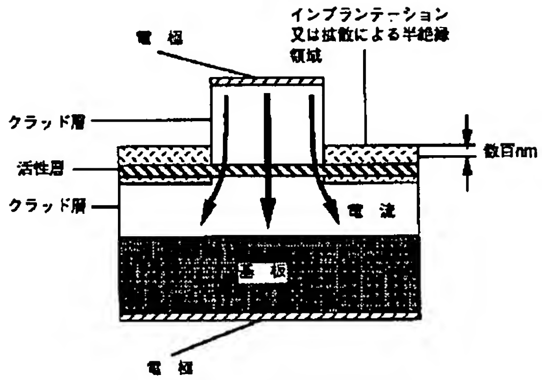
[Drawing 6]

図 6



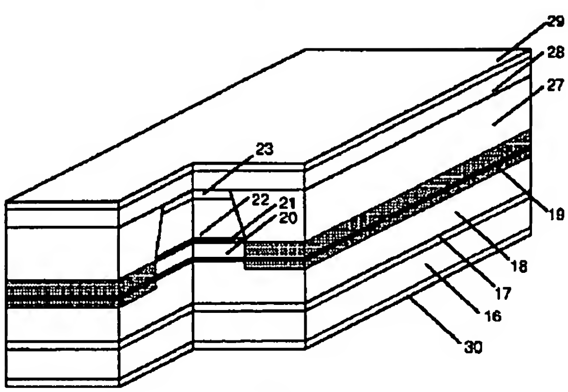
[Drawing 7]

図 7

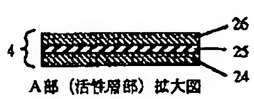


[Drawing 3]

図 3



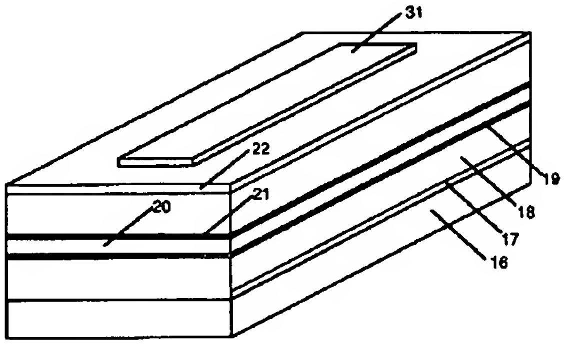
(a)



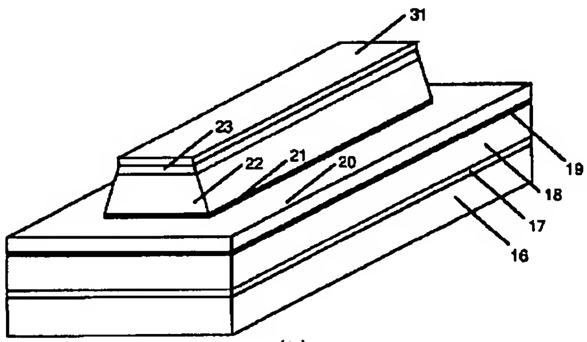
(b)

[Drawing 4]

図4



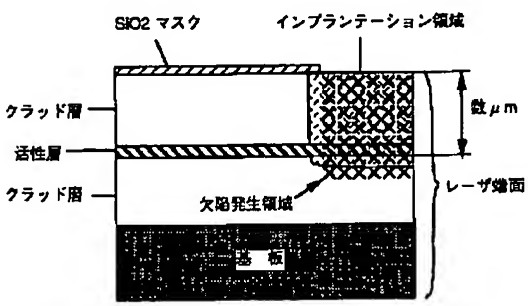
(a)



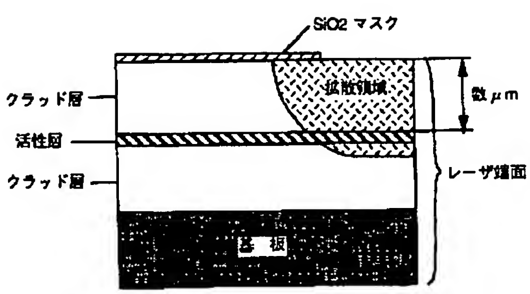
(b)

[Drawing 5]

図5



(a)



(b)